uterus in sagittal plane and, afterwards, utilizing the automatic ultrasound array to sweep over the region of interest.

Conclusions: The quality of the ultrasound images using the 3D probe was superior to the images of the 2D probe. Moreover, the uterine capture, using the 3D probe required less effort than the cumbersome 2D probe. In summary, the 3D probe is a user-friendly and promising alternative as an IGRT system for GYN patients in radiotherapy.

PO-1118

Reproducibility of lung volume with an external surrogate for respiration for deep inspiration breath hold (DIBH)

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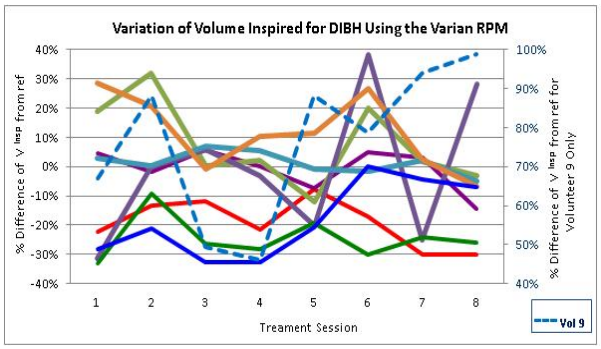
Purpose/Objective: DIBH can reduce heart dose when planning breast RT versus free breathing. Whilst reducing heart dose is an important clinical objective, DIBH must support accurate and reproducible treatment. Inspired lung volume (V^{Insp}) variation was considered an important variable in terms of the impact on set-up accuracy in the DIBH setting. The Varian Real Time Position Management system (RPM) uses a reflective marker block that when positioned on the patient acts as a respiratory surrogate. The aim of this study was to measure the variation of V^{Insp} when performing DIBH with the Varian RPM over a treatment course.

Materials and Methods: 10 staff volunteers were positioned supine on a 15° inclined breast board with both arms raised. The RPM marker block was localised on midline where vertical movement was observed during DIBH coaching. Three DIBHs were acquired within a preparatory session and the largest amplitude selected to set the reference threshold. From this the volunteer was visually coached to acquire the reference DIBH, simulating a 'planning' CT. Each volunteer attended 8 subsequent 'treatment' sessions where they were visually coached to perform 3 DIBHs to the reference amplitude (5mm threshold). For all sessions, V^{Insp} was measured with the SDX® DynR spirometer. Systematic and random error was calculated by analysing the mean and standard deviations of the V^{Insp} for each individual and the entire cohort. Variation was measured as a percentage difference from the reference V^{Insp}.

Results: All volunteers performed 25 second DIBHs with minimal coaching, meeting their RPM amplitude (5mm threshold) for all sessions. Mean time between reference session and first treatment was 14.1 days (range 5 - 28). Mean time to acquire 8 treatment sessions was 72 days (range 35 - 105). 10 reference and 240 treatment DIBH's were acquired. Mean reference RPM amplitude was 21.8mm (range 12.2 - 32.2). Mean reference V^{Insp} was 1.94 litres (range 1.41 - 3.44). Mean total V^{Insp} variation for treatment compared to the reference sessions for the population was 22% (range 0% - 100%). The systematic error in V^{Insp} between reference and treatment sessions for the population was 30% (individual systematic error varied from -25% to 74%) and random error between the reference and treatment sessions for the population was 14% (range 5% - 24%). The population mean was 1%, showing there was no systematic directional error in V^{insp} for the cohort.



Conclusions: DIBH with the Varian RPM is associated with a variation in the volume of air inspired over a treatment course and compared to the reference. The impact of this variation on the dose planned versus that delivered needs further prospective evaluation. Quantifying the dosimetric effect on the heart, lungs, tumour bed and ipsilateral breast when using the Varian RPM for DIBH breast radiotherapy is recommended.

PO-1119

Suitability of lung margins following analysis of set up data within a multi-national lung trial

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Purpose/Objective: To assess suitability of lung margins following analysis of set up data from patients recruited within the **C**oncurrent **ON**ce-daily **VE**rsus twice-daily **R**adio**T**herapy (CONVERT) Trial: A 2-arm randomised controlled trial of concurrent chemo-radiotherapy comparing twice-daily and once-daily radiotherapy schedules in patients with limited stage small cell lung cancer (SCLC) and good performance status (grade 0 to grade 1). Margins outlined within the CONVERT trial define the clinical target volume (CTV) as the gross tumour volume (GTV) + 0.5cm in all directions and the planning target volume (PTV) as the CTV + 0.8cm anterior-posterior (A/P) and left-right (L/R) plane, and 1.0cm in the superior-inferior (S/I) plane. The impact of gender or immobilisation device on margins was also assessed.

Materials and Methods: At this institution ninety patients were recruited, planned and treated within the CONVERT trial. Patients were treated supine, either with a 5 point immobilisation shell or with both arms positioned above their head on a lung board. Knee bolsters were used for added comfort. Cone Beam Computed Tomography (CBCT) images using Elekta Synergy ™ - version 4.5 were acquired during treatment for the first 3 fractions and then at least weekly thereafter following a systematic error reduction strategy

and a 0.5cm action level. Images were fused with bony registries to obtain set up data in the S/I, A/P and L/R planes. Random (s) and systematic (S) errors were calculated. Margins required to account for set up error were calculated using the margin recipe of Van Herk et al, m_{ptv} = aS + bÖ(s^2 + s_p^2) - bs_p, with a=2.5, b=1.64, and penumbra width s_p=0.6cm in lung tissue.
Further analysis between genders and immobilisation was conducted where this information was available.

Results:

		Lat (cm)	S/I (cm)	A/P (cm)
All CONVERT patients (90)	Random error (σ)	0.25	0.33	0.13
	Systematic error (Σ)	0.21	0.22	0.22
	Margin	**0.60**	**0.68**	**0.56**
Male (51)	Random error (σ)	0.24	0.28	0.13
	Systematic error (Σ)	0.22	0.22	0.22
	Margin	**0.62**	**0.66**	**0.59**
Female (39)	Random error (σ)	0.27	0.38	0.14
	Systematic error (Σ)	0.19	0.21	0.21
	Margin	**0.56**	**0.69**	**0.55**
Lung Boards (66)	Random error (σ)	0.25	0.33	0.13
	Systematic error (Σ)	0.21	0.22	0.23
	Margin	**0.61**	**0.68**	**0.60**
5 Point (6)	Random error (σ)	0.22	0.28	0.16
	Systematic error (Σ)	0.21	0.23	0.13
	Margin	**0.60**	**0.67**	**0.36**

Conclusions: Once corrections have been applied to reduce systematic errors, margins used for SCLC patients treated as part of the CONVERT trial were found to be adequate to ensure good PTV coverage during treatment, indicating a potential for reduction. However, other sources of error would need to be accounted for including tumour motion and delineation error. Data for male versus female patients demonstrated minimal difference in set up errors between the genders. Figures for patients with 5 point immobilisation showed smaller A/P systematic error, although numbers were small for this group. Further work and continual audit is needed.

PO-1120

4D-CBCT in lung SBRT: characterization and validation using 6D motion platform and antropomorphic phantom

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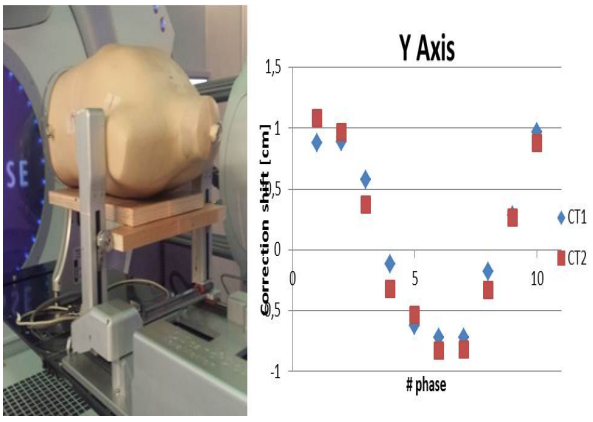
Purpose/Objective: Our purpose was to investigate the accuracy of a 4D-CBCT system to raise the accuracy of daily IGRT in patients undergoing lung SBRT, firstly validating the 4D-CBCT phase binning algorithm, and secondly investigating the correlation between the data-based breathing signal (4D-CT with external surrogates) and the image-based breathing signal (4D-CBCT with internal surrogates).

Materials and Methods: We used the 6D Hexamotion platform from Scandidos, able to simulate the 4D movement of the phantom according to the respiratory cycle of a patient obtained from a 4DCT. This platform was modified in order to allow positioning and motion of an anthropomorphic phantom (CIRS Anthropomorphic Torso Phantom) (fig 1.a). We created two different respiratory patterns to the phantom in order to simulate an actual patient lung motion, both of them with 2 cm extension in the anterior-posterior and superior-inferior direction. The first pattern used a longer inhale phase (with a peak at the series 30%), while the second pattern used equal inhale and exhale phases (with the peak at the series 50%). We performed a 4D-CT scan to the moving phantom for both motion patterns; measuring the external abdominal movement as a surrogate for the internal movement, ten series of images were obtained for each respiratory cycle phase. Each image series was imported in a Treatment Planning System in order to simulate an actual patient treatment workflow, generating body contours and adding a plan. The moving phantom then underwent a 4D-CBCT for each motion pattern. The phase binning of the CBCT was made through the automatic recognition of the diaphragm in the patient/phantom. All different ten 4D-CBCT series were registered with the reference CT (the planning CT), resulting in a detailed summary of phantom's shifts for each phase. The CBCT system allowed the reconstruction and export of a Mid-Ventilation CBCT (MidCT); by mean of rigid registration we identified the CT series more similar to the MidCT.

Results:

Fig 1.b shows the displacement of the phantom position in each respiratory phase respect to different reference CT images (one axis for one respiratory pattern). We found a correlation between a particular CT image series and the MidCT: for the first pattern we found that the MidCT was more similar to the 30% image series, and to the 50% for the second pattern



Conclusions: The 4D-CBCT system was able to recognize the ten respiratory phases without any dependency from a specific respiratory pattern (fig 1.b). The maximum inhale phase in the 4D-CT (that depends from respiratory motion pattern) seems to correspond in a better way to the MidCT image series. Further investigations are needed to consolidate the statement regarding the correlation between respiratory pattern and MidCT.